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1896, Aug. 31	+ 34$^{\text{km.}}$
Sept. 16	+ 54
Oct. 3	+ 49
5	+ 44
Nov. 12	+ 4
1897, Feb. 24	+ 3

On the first photograph the spectrum is of essentially normal solar type; on the others it is unmistakably different. There appears to be a second component whose spectrum contains the $H\gamma$ line and the rather prominent iron lines. On the plates of September 16th, October 3d, and October 5th, these lines are shifted toward the violet with reference to the solar-type spectrum; and in the spectra of November 12th and February 24th, they are shifted toward the red.

v Sagittarii.

To the present time we have secured six spectrograms of this star which give the following velocities:—

1896, July 1	− 3$^{\text{km.}}$
1899, Aug. 23	− 31
28	− 28
Sept. 5	− 18
12	+ 2
19	+ 10

These measures may be uncertain to the extent of several kilometers, on account of the peculiar and difficult character of the spectrum.

Acknowledgments are due to Mr. WRIGHT for his skillful assistance in the observations.

W. W. CAMPBELL.

November, 1899.

SPECTROSCOPIC BINARY STARS.

In No. 60 of these *Publications*, I gave a short account of the spectroscopic binary stars known to exist before January, 1898, dividing them into three classes—(1) those known by the periodic partial eclipse of the bright star by a relatively dark companion, that is, the *Algol*-type variables; (2) those known by the periodic doubling of the lines in the star's spectrum, like β *Aurigæ;* and (3) those known by the shifting of the spectral lines alternately toward the red and the violet ends of the spectrum, as compared with the corresponding lines in the artificial spectrum of hydrogen or iron. At that time, the stars of the first class, or *Algol*-type variables, were by far the most numerous, numbering fourteen certainly, and sixteen probably, as compared with five of the second class and only two (or four, if we include δ *Cephei* and η *Aquilæ*) of the third class.

In the past two years so many stars have been added to the list of known spectroscopic binaries that it seems advisable to summarize briefly these additions, especially as the relative numbers in the three classes named have been decidedly changed.

A notable addition to the list of *Algol*-type stars has been made in the star DM + 45° 3062, discovered as variable by Madame CERASKI in 1899, in her study of photographic plates taken by M. BLAJKO, assistant in the observatory at Moscow. This discovery has been verified by numerous observers and the period of $4^{d}.572$ determined with accuracy. The remarkable feature in this star is the range of variability — the maximum brightness being 8.6 magnitude, the minimum only 11.5.

Two other *Algol*-type variables have been announced — DM + 12° 3557, a star having a period of only $21^{h}\ 21^{m}$, and a range of magnitude from 7.0 to 7.5, by SAWYER in 1898; and CPD — 41° 1681, a star ranging from 9.5 magnitude to 10.7 in 12.906 days, by INNES in the present year. So far as I know, these have not been verified by other observers.

No additions have been made to the second class of spectroscopic binaries, if we except *Capella* (α *Aurigæ*), whose binary character was discovered by CAMPBELL, by the shifting of the spectral lines. Subsequent examination has proved the spectrum to be composite, and some of the lines appear double at regular intervals.

It is to the binaries of the third class — systems consisting of a bright star and a relatively dark companion whose orbital plane is so inclined to the line of sight that no eclipse occurs, and which are hence known only by the periodic shifting of the lines of the bright star's spectrum — that the most numerous and important additions have been made. Of this class but two were known previous to 1898, α *Virginis* and α *Geminorum*. In the past two years BELOPOLSKY has added two, and CAMPBELL fourteen, in addition to the independent discovery of ζ *Geminorum*,* which is credited to BELOPOLSKY.

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* This star, with δ *Cephei* and η *Aquilæ*, should perhaps be classed separately, having been supposed to be binary systems from the regular character of their light variations long before the spectroscope proved their variable velocity in the line of sight.

This list now stands as follows:—

Star.	Discoverer and Date.	Period.
α *Virginis*	Vogel, 1890	4.0134 days.
δ *Cephei*	Belopolsky, 1894	5⅓ days.
η *Aquilæ*	“ 1895	7⅙ days.
α′ *Geminorum*	“ 1896	2.91 days.
η *Pegasi*	Campbell, 1898	2¼ years.
χ *Draconis*	“ “	9⅓ months.
o *Leonis*	“ “	14½ days.
ζ *Geminorum*	Belopolsky* 1898	10⅙ days.
θ *Ursæ Majoris*	“ 1899	5 to 7 days.
i Pegasi	Campbell, 1899	10 + days.
θ *Draconis*	“ “	9 + days.
ε *Libræ*	“ “	Unknown — several months.
β *Capricorni*	“ “	Unknown — long.
h Draconis	“ “	Unknown.
λ *Andromedæ*	“ “	20 days ±
ε *Ursæ Minoris*	“ “	Several weeks.
ω *Draconis*	“ “	Unknown.
α *Ursæ Minoris (Polaris)*	“ “	$3^d\ 23^h$ ±
α *Aurigæ (Capella)*	“ “	3½ months.
v Sagittarii	“ “	Several weeks.

Of the spectroscopic binaries known before 1898, only one had a period exceeding ten days, viz.: ζ *Ursæ Majoris*, which completes a revolution in about fifty-two days. But of those found recently, several have periods of a number of months, and one — η *Pegasi* — a period of two and one-quarter years. There is, therefore, no longer a gap in this respect between the spectroscopic binaries and those known visually. It is also of interest to note that the proportion of known spectroscopic binaries to the stars whose velocities in the line of sight have been well determined indicates that these systems are at least as numerous as visual binaries. R. G. Aitken.

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* In January, 1899, Professor Campbell found that the velocity of ζ *Geminorum* in the line of sight was variable, and announced his discovery in the *Astrophysical Journal*, (vol. IX, p. 86). This announcement called forth a note by Professor Belopolsky in *Astronomische Nachrichten* (3565), in which he stated that he had anticipated this discovery by a year, and had made a statement concerning it at a meeting of the Russian Astronomical Society in February, 1898. Campbell's discovery was, however, entirely independent, as no notice of Belopolsky's investigations had been published, so far as known here.

November, 1899.

Comet *e*, 1899 (Giacobini).

This comet was discovered by M. Giacobini, at Nice, on September 29th, $7^h\ 30^m$ Gr. M. T., in $\alpha\ 16^h\ 26^m\ 32^s$, $\delta - 5^\circ\ 10'$. It was moving slowly east and north. From the Königsberg observation of October 1st and my own of October 7th and 16th, I have computed the following system of parabolic elements:—

$$T = 1899 \text{ Sept. } 15.0430 \text{ G. M. T.}$$

$$\left.\begin{array}{l}\omega = 10^\circ\ \ 51'\ \ 55''.9\\ \Omega = 272\ \ \ 12\ \ \ 32\ .1\\ i = 76\ \ \ 55\ \ \ 18\ .8\end{array}\right\}1899.0$$

$$\log q = 0.251754$$

These elements gave residuals for the middle place as follows:

Obs. - Comp: $\Delta\lambda'\cos\beta'$ $+8''.9$
$\Delta\beta'$ $+1\ .8$

On December 1st the comet's position will be

$\alpha\ 18^h\ 6^m$ $\delta + 12^\circ\ 32'$

It will still continue to move northeast.

At the time of discovery the comet was faint, being estimated at 10½ or 11 magnitude on October 2d. It was 1′ in diameter, and had a faint nucleus. On December 1st its theoretical brightness will be 0.47, that at discovery. It has faded gradually. The last observation was secured on November 23d, when it was estimated at thirteenth magnitude. On that date the deviation from the above orbit was

Obs. - Comp: $\alpha - 3^s$
$\delta - 0'.4$

This is the third comet discovered by M. Giacobini.

Mt. Hamilton, November 28, 1899. C. D. Perrine.

Tempel's$_2$ Comet.

This comet was last observed on November 22d. It was then about ½′ in diameter and of fourteenth magnitude.

Holmes's Comet.

The last observation of this comet was secured on November 6th. It was estimated as fifteenth magnitude.

Mt. Hamilton, November 28, 1899. C. D. Perrine.